REPORT OF GEOTECHNICAL INVESTIGATION
TALL CHIEF COUNTRY CLUB
KING COUNTY, WASHINGTON
S&EE JOB NO. 434
DECEMBER 14, 2004

MAIN FILE COPY

S&EE
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December 14, 2004

Mr. James Zogg
C/O Lang Associates
10658 Riviera Place NE
Seattle, WA 98125
Attn: Mr. De-En Lang

Report
Geotechnical Investigation
Tall Chief Country Club
King County, Washington

Dear De-En:

We are pleased to present herewith our Report of Geotechnical Investigation for the referenced project. Our services were authorized by Mr. James Zogg on November 22, 2004, and have been provided in accordance with our proposal dated November 19, 2004.

We appreciate the opportunity to provide our services. Should you have any question regarding the contents of this report or require additional information, please call.

Very truly yours,
SOIL & ENVIRONMENTAL ENGINEERS, INC.

CHARNG-JENG SHIN
STATE OF WASHINGTON
28166
REGISTERED
PROFESSIONAL ENGINEER
EXPIRES: NOV. 2006

Charng-Jeng Shin
12-14-04

C. J. Shin, Ph.D., P.E.
President

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REPORT OF GEOTECHNICAL INVESTIGATION
TALL CHIEF COUNTRY CLUB
KING COUNTY, WASHINGTON

for
Tall Chief Golf, Inc.

1.0 INTRODUCTION

We present in this report the results of our geotechnical investigation for the proposed development. The site is roughly 191 acres in size and currently occupied by Tall Chief Golf course in King County, Washington. We understand that the proposed development will involve 18 single-family lots. The exiting access road from the West Snoqualmie River Road to the northern portion of the golf course will be widened and a new road is proposed from the west end of this access road to the south end of the residential development (see Figure 1). The grading plan is not available at the time of this report. However, we anticipate that the maximum cut and fill will be on the order of 10 feet. For the purpose of this study, we have assumed that the structural load of future houses will be typical of residential homes. All references to road alignments and lot numbers are based on "Land Use Study Plan-Tall Chief County Club" prepared by Lang Associates, Inc. dated November 22, 2004.

2.0 SCOPE OF SERVICES

The purpose of our geotechnical investigation is to develop recommendations regarding site preparation and foundation support. Specifically, our services included:

1. Review of available geologic information for the site and its vicinity.

2. Site reconnaissance to observe surface conditions including obvious signs of slope instability and wet and unstable soils.

3. Exploration of soil and groundwater conditions underlying the site through the excavation of 13 test pits.

4. Recommendations regarding type of foundation support. Our recommendations include allowable soil-bearing pressure and the total and differential settlements.

5. Recommendations regarding potential impacts of groundwater on site development.

6. Recommendations regarding the roadway construction.

7. Evaluation of the stability of the onsite slopes, recommendation regarding setback and mitigations.

8. Recommendations regarding active and at-rest earth pressures to be used for the design of any retaining structures.

9. Recommendations regarding site preparation, including removal of unsuitable soils, suitability of onsite soils for use as fill, fill placement techniques, and compaction criteria.

10. Five copies of a written geotechnical report containing a site plan, test pit logs, a description of subsurface conditions, and our findings and recommendations.

3.0 SITE CONDITIONS

3.1 SURFACE CONDITIONS

The property is located at the west bank of Snoqualmie River about 2 miles northwest of Fall City, Washington. Topographically, the site includes a flat, low-lying area in the northeastern portion and east-facing hillsides in the western and southern portions. The low-lying area is located within a 100-year flood plain. From this area westward, the grade rises to a long and narrow bench that flanks the foothill. The slope on this bench varies from about 10 to 25 percent. Most of the new residential lots will be constructed on this bench and a new road is proposed along the east side of this bench. The rise from the flood plain to this bench is relatively gentle in the northern 1/3 of the site, whereas the rise is relatively steep (about 30 to 40 percent) in the southern 2/3 of the site. From the west side of the bench, the grade ascends steeply westward for about 80 to 120 vertical feet with 40 percent or steeper slopes. The grade becomes a gentle slope from the top of this steep slope to the west property line. The slopes here rises about 80 to 150 vertical feet with 15 to 30 percent slopes. Five new lots (10 and 15 to 18) are proposed on this gentle slope.

At the time of this report, all slopes are covered with dense trees and thick undergrowth. During our site reconnaissance, we observed some localized slumps in the areas of steep slopes. These slumps appeared to be the result of previous sloughing that occurred within the upper 5 to 10 feet of the slope surfaces. We did not observe any obvious signs of deep-seated slope instability which typically include tilting trees, hummocky terrains, and cracks and fissures at the ground surface.

3.2 SOIL SURVEY

Published soil survey (*King County Area, Washington by United States Department of Agriculture, Soil Conservation Service, 1973*) indicates that the low lying area of the site is covered by Nooksack silt loam (Nk), and the hill area is covered by Alderwood and Kitsap soils. The latter has a severe to very severe erosion hazard.

3.3 GEOLOGY

Published geologic information (*Surficial Geologic Map of The Skykomish and Snoqualmie Rivers Area, Snohomish and King Counties, Washington, by Derek B. Booth, 1990*) indicates that the low lying area and the hill are underlain by alluvial and glacial deposits, respectively. The latter include Advance Outwash in the area of lower elevations (below 300 feet) and Vashon till in the area of higher elevations (above 300 feet). The outwash is typically a dense sand and gravel, and the till is typically a hard, unsorted mixture of clay, silt, sand and gravel.

3.4 SUBSURFACE CONDITIONS

Due to the on-going operation of the golf course, no test pits were excavated in the flood plain. However, based on the geologic information and our experience with the flood plain deposits we anticipate that compressible soils are present in the area. The soil conditions underlying the hillsides were explored by the excavation of 13 test pits on November 30 and December 1, 2004. The approximated test pit locations are shown on Figure 1 - Site and Exploration Plan which is included at the end of this report. Details of the exploration program and the test pit logs are presented in Appendix A of this report.

Our test pits were excavated using a trackhoe to depths of 8 to 15 feet below the current ground surface. These test pits indicate that the hillsides are underlain by fine-grained soils that include silt and silty clay. These soils almost daylight at the ground surface on the narrow bench where Lots 1 to 9 and 11 to 14 are proposed as shown on Land Use Study Plan dated 11/22/04. On the other hand, these fine-grain soils are covered by about 5 to 10 feet of coarse-grained soils (sand, silty sand and gravel) in the western and upper portion of the hill where Lots 10 and 15 to 18 are located. In general, the silt and clay are stiff to very stiff in the western and upper portion of the hill and becomes medium stiff to stiff or occasionally soft in the lower eastern portion. Our test pits found that the silt and clay in the lower eastern portion of the site contains water-bearing sand lenses (less than one inch in thickness) and layers (less than one foot in thickness). The strength reduction of the silt and clay appears to be the softening effect resulting from the moisture in the water-bearing sand.

The coarse-grained soils that cover the silt and clay in the western, upper portion of the hillside are about 2 to 7 feet in thickness. The exception to this is at TP-6 and TP-8 where the coarse-grained soils are at least 11 and 9 feet in thickness, respectively. The materials include, silty sand, sand and gravel with varies amount of cobbles. The upper 5 feet of this unit is typically un-cemented and medium dense. We believe that a large portion of this unit represents colluviums that were re-deposited by gravity in the past.

The topsoil layer is generally 12 to 24 inches in thicknesses.

3.5 GROUNDWATER

Groundwater seepage was encountered in TP-3 and TP-4. The seepage rates were minor to moderate, about ½ gallon per minute from the test pit side walls. Water-bearing sand lenses and layers were encountered in the silt and clay in TP-1, TP-3, TP-4, TP-7 and TP-9. At the time of our test pit excavation, these water-bearing lenses and layers did not produce any seepage, however, the moisture in the sand often caused the surrounding silt and clay to soften, especially when disturbed.

We believe that the seepage rate will vary with season and precipitation. However, the moisture condition in the silt and clay may not change much between the dry and wet months as these fine-grained soils have a very low permeability and high internal capillary force. That is, they have a great capacity to draw moisture and keep it between particles.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 GENERAL

1. The development of the subject site is feasible from a geotechnical standpoint. The hillsides are currently stable except for a minor potential of shallow sloughing on and adjacent to the steep slopes. Provided that the recommendations in this report are followed, we believe that the potential of future slope instability will be very low. Please be aware that there is always an inherent risk of slope movement for any development near or on slopes. In addition to natural factors (soil, groundwater, heavy rainfall), other factors that may affect stability include excavations, fills, leaking or broken utility, improper drainage, lack of maintenance of drainage facilities or vegetation cover, unwise actions by adjacent property owners, or similar events or unknown conditions that may cause instability. Therefore, future property owners must be alert of any adverse impacts on the slope stability and take appropriate actions when necessary.

2. The expansion of the existing access road and a portion of the new road will be constructed in the flood plain. Although no test pit was excavated in the area, it is anticipate that compressible soils are present and the consolidation of these soils may cause premature pavement failure, if not mitigated. Our recommendations include a thickened road base and surcharge preload.

3. The new road above the flood plain will be constructed over potentially unstable soils. These soils consist of silt and clay with lenses and layers of water-bearing sand. The materials are very susceptible to strength loss due to disturbance and increase moisture. Our recommendations include a thickened road base and roadside drainage.

Details of our recommendations are presented in the following sections.

4.2 DRAINAGE CONTROL, BUFFER AND SETBACKS

BUFFER AND SETBACK

Buildings: We recommend a no-disturbance (buffer) zone of 25 feet from the top and toe of steep slope (over 40%), and a building setback of 15 feet from the buffer. No grading and clearing shall be allowed in the buffer. The existing vegetation in the buffer and on the steep slope should be protected.

Roads: A large portion of the new road will be constructed along the eastern edge of the foothill. The subsoils here are predominately fine-grained soils with lenses and layers of water-bearing sand. These soils and the slopes in the area can become unstable when wet or disturbed. We thus recommend the following setbacks from edge of pavement to the top of slopes:

40% slope: 15 feet
30% slope: 10 feet
20% slope: 5 feet

Recommendations for roadway construction including thickened road base and drainage along the road are presented in **Section 4.9 ROADWAY CONSTRUCTION** of this report.

DRAINAGE CONTROL

In general, the site development will decrease infiltration and increase surface runoff. Such change of flow patterns may cause concentrated flow at the edges of steep slopes. Since the hillsides are mantled by granular soils over relatively impermeable silt and clay, the increased groundwater flow must be handled to avoid adverse impacts on slope stability. A surface water drainage swale and a subsurface groundwater interceptor drain (frenchdrain) are commonly used for hillside development. We believe that they would work well for the drainage control for the current project. The swale and frenchdrain should be constructed outside of the above-mentioned buffer, along the east side of Lot 10 and 15 to 18. The swale should be located upslope from the frenchdrain with a horizontal space of at least 5 feet between the two systems. The frenchdrain should be at least 8 feet in depth. Most of the trench subgrade will be excavated into the fine-grained soils. Permeable granular soils may be encountered at isolated locations along the trench. When this occurs, the bottom 12 inches of the trench should be lined with a 20-mil PVC liner.

A perforated drain pipe of at least 8 inches in diameter should be installed at the bottom of the frenchdrain and the trench should be backfill with open-coarse crushed rock such as 2-inch ballast rock. The water in the swale and the frenchdrain should not be combined until they are connected to the discharge pipe. The ideal outfall location is the base of the hill (edge of flood plain). The design of the drainage system including the outfall location should be approved by S&EE, Inc. and the construction of the swale and frenchdrain should be monitored by an engineer from our office.

Except for the septic system, infiltration should be avoided and water should not be allowed to flow over steep slopes. We understand that stormwater infiltration may be considered for the new development to the west of the site. Since this development is upslope from the current project, any infiltration may incur adverse impact on the current project and should be evaluated in the future. If necessary, a line of groundwater interceptor drain may be considered near the western site boundary.

4.3 MITIGATION OF EROSION HAZARDS

Other than the flood plain the entire site area is susceptible to erosion. We recommend that an Erosion Control and Sediment Management Plan be installed for the construction period. This plan should include methods of interception, collection and discharging of stormwater so that runoff would not sheet flow over denuded areas and cause erosion. The erosion and sediment control methods presented in King County Surface Water Design Manual should be considered.

We further recommend that a wet-season erosion control plan be prepared prior to October 1. Depending on the site conditions at the time, the plan should include, as a minimum, the covering method for all denuded areas. The local authorities may request a Temporary Erosion and Sediment Control (TESC) monitoring program throughout the wet season (from October 1 to April 30). We recommend that this wet-season erosion control plan be prepared and the TESC monitoring be performed by a qualified geotechnical engineer, if needed.

4.4 FOUNDATION SUPPORT

We recommend that all structures be supported by conventional spread footings. The footings must be founded on structural fill or at least medium dense native soils. Please note that our test pits were loosely filled with the excavated soils. If these test pits coincide with the future footing locations, the upper 4 feet of the fill in the test pits should be removed, and then the pit backfilled with structural fill. The criteria for structural fill are presented in **Section 4.10 SITE PREPARATION AND STRUCTURAL FILL.** Details of our recommendations regarding the footing design are presented below.

Bearing Capacity: We recommend an allowable bearing pressure of 3,000 pounds per square feet (psf) for the footing design. This value includes a safety factor of at least 3, and can be increased by one-third for wind and seismic loads.

Footing Construction: The footing bearing materials will be moisture sensitive and susceptible to strength loss due to wetting and disturbance. As such, the footing bearing surfaces should be protected from weather and disturbance, and all organic, softened and loosened soils must be removed by over-excavation. Any over-excavation at the footing subgrade should be backfilled with structural fill, concrete, lean concrete or crushed rock. The crushed rock, if used, should be placed in 6 inches thick lifts and compacted by at least three passes of a compactor weighing greater than 200 pounds.

All footing subgrade should be inspected by a qualified geotechnical engineer prior to re-bar and concrete placements.

All exterior footings should be founded at least 18 inches below the adjacent finished grade to provide protection against frost action, and should be at least 18 inches in width to facilitate construction.

Settlement: Interior column footings designed in accordance with the above recommendations are expected to experience approximately 1/2 inch of settlement. Continuous wall footings should experience about 1/4 to 1/2 inch. Differential settlement between adjacent footings is expected to be 1/4 to 1/2 of an inch.

Lateral Resistance: Lateral resistance can be obtained from the passive earth pressure against the footing sides and the friction at the contact of the footing bottom and bearing soil. The former can be obtained using an equivalent fluid density of 250 pounds per cubic foot (pcf), and the latter using a coefficient of friction of 0.5. These values include a safety factor of 1.5.

Footing Near Slopes: For any footings near slopes of 20 percent or steeper, the bottom of the footing must be positioned in such a way that the horizontal distance from the outside footing edge to the slope face is at least 12 feet.

Footing Drain: Rigid, perforated drainpipes should be installed around all perimeter footings. Drainpipes should be at least 4 inches in diameter, covered by a layer of uniform size drain gravel of at least 12 inches in thickness, and be connected to a suitable discharge location. An adequate number of cleanouts should be installed along the drain line for future maintenance. **Footing drains should be separated from roof drains.**

4.5 SLAB SUPPORT

All slabs-on-grade can be supported on structural fill or at least medium dense native soils. We envision that the soil at the slab subgrade will be disturbed and loosened by construction activities at the time of slab construction. We therefore recommend that the slab subgrade be proof-rolled or probed just before pour. Any wet and loose areas should be over-excavated and backfilled with structural fill.

In order to promote uniform support and provide a capillary break, we recommend that slabs be underlain by a 6 mil. vapor barrier over a 4-inch thick layer of free draining gravel.

4.6 LATERAL EARTH PRESSURES

Lateral earth pressures on retaining walls or permanent subsurface walls, and resistance to lateral loads may be estimated using the following recommended soil parameters:

Soil Density (PCF)	Equivalent Fluid Unit Weight (PCF)			Coefficient of Friction
	Active	At-rest	Passive	
130	30	45	250	0.5

Note: 1) Hydrostatic pressures are not included in the above lateral earth pressures.
2) Lateral earth pressures are appropriate for level structural fill placed behind and in front of walls.

The active case applies to walls that are permitted to rotate or translate away from the retained soil by approximately 0.002H, where H is the height of the wall. This would be appropriate for a cantilever retaining wall. The at-rest case applies to unyielding walls, and would be appropriate for walls that are structurally restrained from lateral deflection such as basement walls, utility trenches or pits.

Additional lateral earth pressures will result from surcharge loads from floor slabs or pavements for parking that are located immediately adjacent to the walls. The surcharge-induced lateral earth pressures are uniform over the depth of the wall. Surcharge-induced lateral pressures for the "active" case may be calculated by multiplying the applied vertical pressure (in psf) by the active earth pressure coefficient (Ka). The value of Ka may be taken as 0.3. The surcharge-induced lateral pressures for the "at-rest" case are similarly calculated using an at-rest earth pressure coefficient (Ko) of 0.5.

Appropriate earth pressures must be provided by S&EE, Inc. for sloping backfill behind and in front of retaining walls.

DRAINAGE AND BACKFILL OF RETAINING WALLS

Retaining walls should be backfilled with free-draining materials which are typically granular soils containing less than 5 percent fines (silt and clay particles) and no particles greater than 4 inches in diameter.

The backfill material should be placed in 6 to 8-inch thick horizontal lifts and compacted to at least 90 percent of the maximum density in accordance with ASTM D-1557 test procedures. In the areas where the fill will support pavement, sidewalk or slabs, the top two feet of the backfill should be compacted to at least 95 percent of the maximum density. Care must be taken when compacting backfill adjacent to retaining walls, to avoid creating excessive pressure on the wall.

Rigid, perforated drainpipes should be installed behind retaining walls. Drainpipes should be at least 4 inches in diameter, covered by a layer of uniform size drain gravel of at least 12 inches in thickness, and be connected to a suitable discharge location. An adequate number of cleanouts should be installed along the drain line for future maintenance.

4.7 ROCKERY WALLS

In addition to concrete retaining walls, reinforced or non-reinforced rockery walls can be considered for grading purposes. Please note that rockery walls should be designed by a geotechnical engineer for the following conditions:

1. The wall will be used to retain fill.
2. The surface behind the wall is not level.
3. The wall will retain a cut embankment greater than 6 feet in height.

The design should consider the slope behind the wall, the wall height, the surcharge load behind the wall, and the strength of the reinforcing material (if required). We will be glad to perform this design, if requested.

4.8 TEMPORARY AND PERMANENT EXCAVATIONS

When temporary excavations are required during construction, the contractor should be responsible for the safety of their personnel and equipment. The followings cut angles are provided only as a general reference:

For temporary excavations less than 4 feet in depth, the cut bank may be excavated vertically. For temporary excavations greater than 4 feet in depth, the cut can be 1H:1V. Flatter slopes for all temporary cuts may be required if seepage occurs.

All permanent slopes should be no steeper than 3H:1V. Water should not be allow to flow uncontrolled over the top of any slope. Also, all permanent slopes should be seeded with the appropriate species of vegetation to reduce erosion and maintain the slope stability.

4.9 ROADWAY CONSTRUCTION

4.9.1 Road within Flood Plain

This portion of the road includes the widening of the existing access road and the construction of the new road in the northern part of the development. Soft and compressible soils are anticipated in the flood plain. Settlement will occur by compression of these soils under increased surface loads. The compression includes primary and secondary consolidations. The latter depends on amount of organic matter in the soil. Elimination of consolidations is possible but economically non-feasible. We believe that the best mitigation action is to apply a surcharge preload in the area of the road. Since consolidation effects (especially the secondary consolidation) can never be completely removed by a surcharge preload, a thickened road base is a practical way to further mitigate the adverse impact.

The thickened road base should consist of 2 feet thick, granular select fill placed over the prepared subgrade. The top edges of this base should be at least 2 feet beyond the edges of the pavement. The pre-load should consist of 5 feet thick of surcharge fill placed over the base. The edges of the surcharge fill should be no steeper than 1H:1V and the top of the slope should also be at least 2 feet beyond the edges of the pavement. The criteria for subgrade preparation, select fill and surcharge fill can be found in Section **4.10 SITE PREPARATION AND STRUCTURAL FILL.**

The settlement should be monitored in order to determine the maturity of primary consolidation. A sketch showing the settlement marker is included in Figure 2. We recommend that one settlement marker be installed for every 200 feet of the road. Care should be taken to protect these markers from disturbance by construction equipment. The markers should be surveyed initially prior to the placement of any fill, then weekly after the completion of the fill placement. Settlement readings should be transmitted to and evaluated by S&EE, Inc. We anticipate that a primary settlement of about 4 to 6 inches will occur under the pre-load in 8 to 12 weeks. Upon completion of the primary settlement the surcharge fill may be removed. Please note that the secondary settlement will still occur but its magnitude will be reduced by prolonged primary consolidation. Therefore, it is advantage to keep the pre-load in place as long as possible.

4.9.2 New Road outside Flood Plain

As previously mentioned, the southern portion of the new road will be constructed along the top of slopes. The soils in the area consist of silty and clayey, fine-grained soils with lenses and layers of water-bearing sand. These materials are very susceptible to strength loss due to disturbance and increase moisture. Therefore, construction in wet months should be avoided and setbacks from the top of slopes are recommended. **(See Section 4.2 for details).**

In addition, a thickened road base consisted of 12 inches thick structural fill is recommended. The criteria of structural fill are presented in the next section. A surface water drainage swale should be installed along the uphill (west) side of the road. The bottom of this swale should be at least 3 feet below the roadway subgrade. Water should be discharged to the bottom of the hill (edge of flood plain).

4.9.3 New Road across Ravine

The new road will across an existing ravine at the east side of Lot 7. We envision that the road base can be built with new structural fill placed in the ravine. The criteria of structural fill are presented in the next section. Care must be taken in preparing the subgrade. In general, all vegetation and topsoil should be removed and the slope faces should be benched as every few lifts of the fill are placed. Subsurface drains may be needed in strategic locations to avoid buildup of hydrostatic pressure in or behind the fill embankment. The subgrade preparation, fill operation and installation subsurface drains should be monitored by an engineer from our office.

4.10 SITE PREPARATION AND STRUCTURAL FILL

We recommend that areas of structures and roads be stripped of vegetation, tree roots, and topsoil. All underground utilities should also be removed. After stripping and excavation, subgrades of slabs, pavement, or areas to receive new fill should be thoroughly proof-rolled using heavy construction equipment. If the subgrade is wet and proof rolling is not feasible, the area should be probed using a steel bar so as to avoid disturbance and rutting of the subgrade soils. Areas which are found to be loose or soft, or which contain organic soils should be over-excavated. Geotextile can be considered in areas where over-excavation is not suitable.

The proof-rolling and/or probing should be observed/performed by an engineer from our office. Our engineer will evaluate the over-excavation requirements and provide recommendation regarding the use of geotextile, if needed.

After stripping, over-excavation and excavation to the design grade, the top 12 inches of the native soils should be re-compacted to at least 90% of their maximum dry density as determined using ASTM D-1557 test procedures (Modified Proctor test).

Structural fill can then be placed in the over-excavation and fill areas. All fill materials should be approved by S&EE, Inc. prior to use and should meet both the material and compaction requirements presented below.

MATERIAL REQUIREMENTS

Structural Fill: The material should be free of organic and frozen material. The on-site silty sand, sand and gravel are suitable for use as structural fill. These soils are available in the western, higher elevations of the site. The silty sands are moisture sensitive and should be moisture-conditioned to within ± 2% of their optimum moisture content prior to use. Suitable imported structural fill materials include sand, gravel, sand and gravel (pitrun), and crushed rock.. The onsite silt and clay are not suitable for use as structural fill.

Granular Select Fill: The material should be used for the thickened road base that is to be constructed in the flood plain. Only coarse-grained soils such as pitrun, gravel and crushed rock should be used. In general, the material should have a fines (particles size smaller than a no. 200 sieve) content less than 5 percent. Some of the granular soils in the western, upper portion of the site may be suitable. However, the use of onsite soils for select fill must be approved by S&EE, Inc.

Surcharge Fill: The surcharge fill should have an in-place total density of at least 120 pounds per cubic feet. All onsite soils are suitable for use as surcharge fill.

PLACEMENT AND COMPACTION REQUIREMENTS

Structural Fill and Granular Select Fill: The materials should be placed in loose horizontal lifts not exceeding a thickness of 12 inches. Structural fill should be compacted to at least 95% of the maximum dry density as determined using the ASTM D-1557 test procedures. Care must be taken when structural fill is placed on slopes. The procedure requires that the existing slope be benched so that the new fill can be keyed into the slope. We recommend testing the fill as it is placed.

Surcharge Fill: Depending on the material type and equipment used, the surcharge fill should be placed in 12 to 18 inches thick lifts and compacted to least 90% of the maximum dry density as determined using the ASTM D-1557 test procedures.

Excavation subgrade and site surface should be graded so that surface water is directed away from the structural areas. Standing water should not be allowed. Final grades should be sloped away from buildings and roads unless the area is paved.

4.11 SEISMIC CONSIDERATIONS

We recommend that Site Class D as defined in the 2003 IBC be considered for the building design. Liquefaction is a condition when strong vibration or shaking of the ground results in the excess pore pressures in saturated soils and subsequent loss of strength. Liquefaction can result in ground settlement or heaving. In general, soils which are susceptible to liquefaction include saturated, loose to medium dense sands (i.e., below the water table). The liquefaction potential is negligible for areas above flood plain, and high for areas within flood plain. The impact on the roadway will be uneven settlement and thus pavement failure.

Some repair work should be anticipated after strong seismic events, and to provide a design without the need for any repair would be uneconomical. It is our opinion that the thickened road base will provide some capacity to reduce uneven settlement and no additional liquefaction mitigation measures are necessary.

4.12 FLEXIBLE PAVEMENT

We recommend that the subgrade for flexible pavement be prepared in accordance with the recommendations presented in **Section 4.10 SITE PREPARATION AND STRUCTURAL FILL.** Based on the subsoil conditions, we believe that the prepared subgrade will have a California Bearing Ratio (CBR) of at least 10.

We recommend the following flexible pavement sections for light and medium traffic conditions:

Light traffic (Daily EAL = 5 or less): 2 inches asphaltic concrete over 4 inches base course
Medium traffic (Daily EAL = 20 to 80): 3 inches asphaltic concrete over 6 inches base course

The base course should be compacted to at least 95 percent of the maximum dry density as determined by ASTM D-1557 test method. The material should meet WSDOT aggregate specification 9-03.9(3) and have the following gradation:

Sieve Size	Percent Passing
1 ¼-inch	100
5/8-inch	50-80
1/4-inch	30-50
US No. 40	3-18
US No. 200	7.5 max.
% Fracture	75 min.

4.13 ADDITIONAL SERVICES

Additional services may be required during the design and construction of the project. We envision that these additional services may include the following:

1. Review of design plans and response to contractor's questions and county's comments.

2. Provision of rockery wall and other geotechnical designs.

3. Monitoring of site grading and roadway subgrade preparation.

4. Monitoring the installation of surcharge pre-load; evaluation of settlement data and the maturity of primary settlement.

5. Monitoring the installation of surface and subsurface drains; observation and approval of discharge locations.

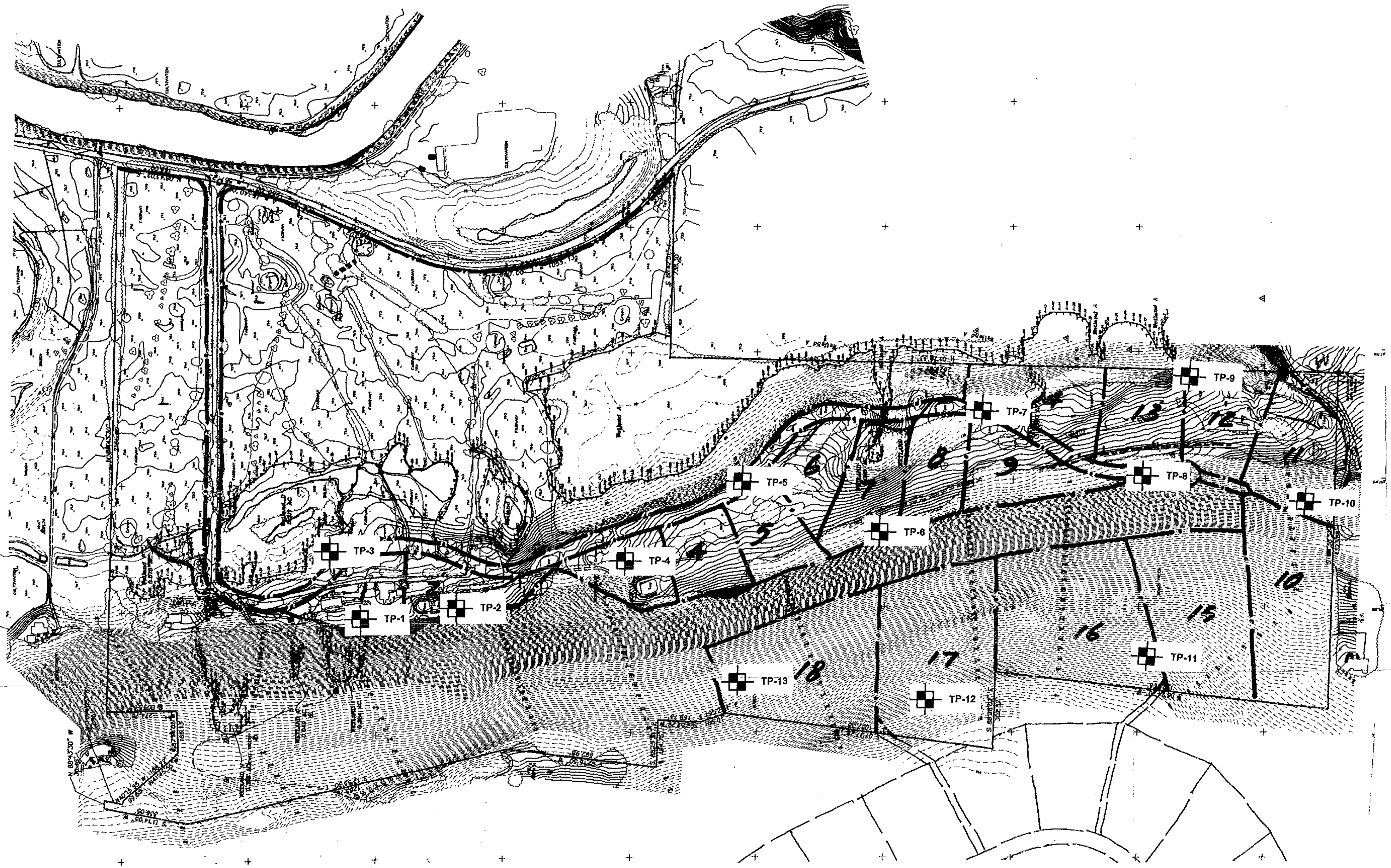
6. Monitoring of foundation subgrade preparation. Our representative will confirm the bearing capacity of the subgrade soils, and will assist the contractor in evaluating the over-excavation requirements, if any.

7. Monitoring the placement and compaction of structural and select fill. Our representative will confirm the suitability of the fill materials, perform field density tests, and assist the contractor in meeting the compaction requirements.

8. Other geotechnical issues deemed necessary.

5.0 CLOSURE

The recommendations presented in this report are provided for design purposes and are based on soil conditions disclosed by field observations and subsurface explorations. Subsurface information presented herein does not constitute a direct or implied warranty that the soil conditions between exploration locations can be directly interpolated or extrapolated or that subsurface conditions and soil variations different from those disclosed by the explorations will not be revealed. The recommendations outlined in this report are based on the assumption that the development plan is consistent with the description provided in this report. If the development plan is changed or subsurface conditions different from those disclosed by the exploration are observed during construction, we should be advised at once so that we can review these conditions, and if necessary, reconsider our design recommendations.



S&EE
Job no. 434

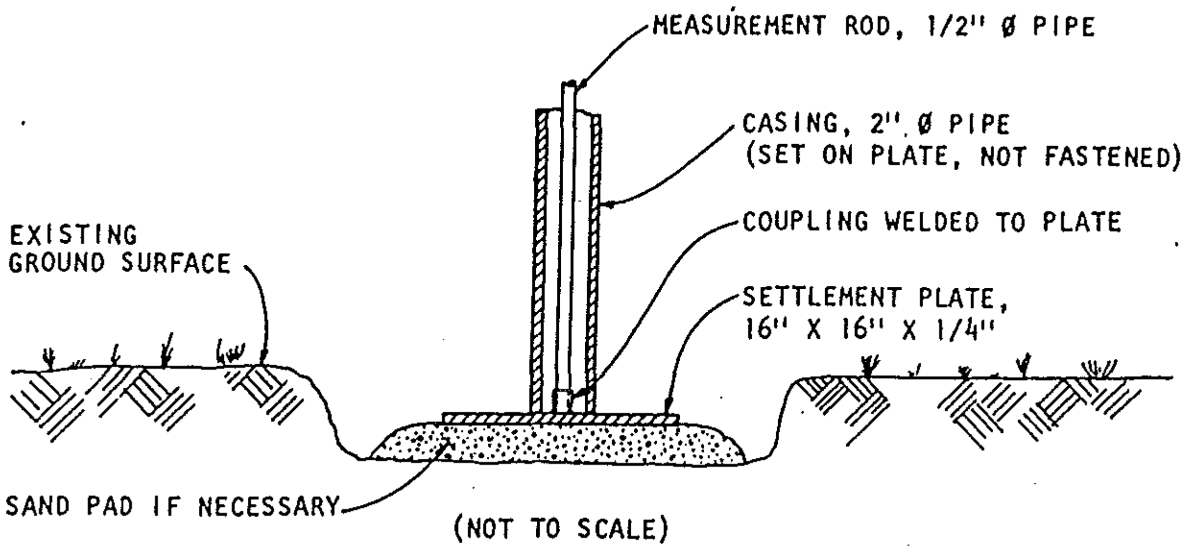
TP-1 Test pit number and location

0 400 800
Scale in Feet

N

Reference: "Topographic/Aerial Map", dated October 12, 2004 and prepared by Harmsen & Associates, Inc.

Figure 1
Site and Exploration Plan
Tall Chief Country Club
King County, Washington



NOTES:

1. INSTALL MARKERS ON FIRM GROUND OR ON SAND PADS IF NEEDED FOR STABILITY. TAKE INITIAL READING ON TOP OF ROD AND AT ADJACENT GROUND LEVEL PRIOR TO PLACEMENT OF ANY FILL.

2. FOR EASE IN HANDLING, ROD AND CASING ARE USUALLY INSTALLED IN 5-FOOT SECTIONS. AS FILL PROGRESSES, COUPLINGS ARE USED TO INSTALL ADDITIONAL LENGTHS. CONTINUITY IS MAINTAINED BY READING THE TOP OF THE MEASUREMENT ROD, THEN IMMEDIATELY ADDING THE NEW SECTION AND READING THE TOP OF THE ADDED ROD. BOTH READINGS ARE RECORDED.

3. RECORD THE ELEVATION OF THE TOP OF THE MEASUREMENT ROD IN EACH MARKER AT THE RECOMMENDED TIME INTERVALS. EACH TIME, NOTE THE ELEVATION OF THE ADJACENT FILL SURFACE.

4. READ THE MARKER TO THE NEAREST 0.01 FOOT, OR 0.005 FOOT IF POSSIBLE. NOTE THE FILL ELEVATION TO THE NEAREST 0.1 FOOT.

Figure 2
Settlement Marker

APPENDIX A

FIELD EXPLORATION AND LOGS

Due to the on-going operation of the golf course, no test pits were excavated in the flood plain. The soil conditions underlying the hillsides were explored by the excavation of 13 test pits on November 30 and December 1, 2004. The approximated test pit locations are shown on Figure 1 - Site and Exploration Plan which is included at the end of this report.

The test pits were excavated with an Hitachi 120-5 EX trackhoe. A representative from S&EE was present throughout the exploration to excavate the pits and log the subsurface soil conditions. Test pit logs are presented in this appendix. A chart showing the Unified Soil Classification System is included at the end of this appendix.

All test pits were backfilled with the excavated soils, which were placed in 2- to 3-foot thick lifts and loosely compacted with the trackhoe bucket. Please note that if these test pits coincide with the future footing locations, the upper 4 feet of the backfill in the test pits should be removed and then backfilled with structural fill.

TEST PIT TP-1

Depth (feet)	USCS Symbols	Soil Description
0	SM	Dark brown topsoil
	SM	Light brown silty fine sand with medium to coarse gravel (moist)(medium dense)
5	SP	Light brown and gray medium to coarse sand with few medium gravel and trace silt (moist)(medium dense)
	ML	Tan and gray silt with silty clay and layers of fine to medium sand (moist to wet)(soft to medium stiff)(sand layers are water-bearing)
10		- torvan reading = 0.5 tsf
		- torvan reading = 0.6 tsf
15		

Test pit completed at a depth of 14 feet on 12-1-04.
No groundwater encountered during excavation.
No caving occured during excavation.

Excavation Method: Hitachi EX120-5 Trackhoe
Excavation Date: December 1, 2004

Figure A-1

TEST PIT TP-2

Depth (feet)	USCS Symbols	Soil Description
0	SM	Brown topsoil
	GP	Light brown sandy and silty medium to coarse gravel (damp)(medium dense)
	ML	Light brown and gray sandy silt with few fine gravel (dry)(stiff)
5	SP	Gray fine to coarse sand with fine to medium gravel, some cobbles and trace silt (dry)(dense)
10	SM	Light gray and tan silty fine sand with fine to medium gravel and cobbles (dry)(dense)
15		

Test pit completed at a depth of 11 feet on 12-1-04.
No groundwater encountered during excavation.
No caving occured during excavation.

Excavation Method: Hitachi EX120-5 Trackhoe
Excavation Date: December 1, 2004

Figure A-2

TEST PIT TP-3

Depth (feet)	USCS Symbols	Soil Description
0	SM	Dark brown topsoil
		- seepage about 1/10 gpm at bottom of topsoil
	ML	Light brown silt with lenses of fine sand (moist)(soft to medium stiff)(sand lenses are water-bearing)
5		
		- seepage about 1/2 gpm
10		- torvan reading = 0.75 tsf
	ML	Gray silt with silty clay and lenses of fine sand (moist to wet)(soft to medium stiff)(sand layers are water-bearing)
		- torvan reading = 0.6 tsf
15		

Test pit completed at a depth of 14 feet on 12-1-04.
Seepage encountered during excavation.
No caving occured during excavation.

Excavation Method: Hitachi EX120-5 Trackhoe
Excavation Date: December 1, 2004

Figure A-3

TEST PIT TP-4

Depth (feet)	USCS Symbols	Soil Description
0	SM	Dark brown topsoil
	ML	Gray and brown mottled silt (damp)(stiff)
	ML	Light brown gravely and sandy silt (moist to wet)(soft to medium stiff) - seepage about 1/2 gpm at 4 to 5 feet
5	ML	Yellowish tan sandy silt with layers of silty clay (moist)(stiff)
10	ML	Gray silt with lenses of fine sand (damp)(medium stiff to stiff)(sand lenses are water-bearing) - torvan reading = 1.0 tsf
15		

Test pit completed at a depth of 15 feet on 11-30-04.
Seepage encountered during excavation.
Some caving occured at 5 feet during excavation.

Excavation Method: Hitachi EX120-5 Trackhoe
Excavation Date: November 30, 2004

Figure A-4

TEST PIT TP-5

Depth (feet)	USCS Symbols	Soil Description
0	SM	Dark brown topsoil
	ML	Mottled gray and tan silt (damp)(medium stiff)
	ML	Grayish tan sandy silt with silty clay and lenses of fine sand (damp)(stiff)
		- torvan reading = 1.0 tsf
5		
10		
		- torvan reading = 1.25 tsf
		Test pit completed at a depth of 13 feet on 11-30-04. No groundwater encountered during excavation. No caving occured during excavation.
15		

Excavation Method: Hitachi EX120-5 Trackhoe
Excavation Date: November 30, 2004

Figure A-5

TEST PIT TP-6

Depth (feet)	USCS Symbols	Soil Description
0	SM	Brown topsoil
	SM	Gray and tan mottled silty fine sand with some fine to medium gravel and occasional cobbles and trace silt (damp)(loose to medium dense)
5	SM	Light gray silty fine sand with fine to medium gravel and few cobbles trace silt (dry to damp)(dense)
	SP	Dark gray medium to coarse sand with fine to medium gravel and few cobbles trace silt (moist)(dense)
10		
15		

Test pit completed at a depth of 13 feet on 11-30-04.
No groundwater encountered during excavation.
No caving occured during excavation.

Excavation Method: Hitachi EX120-5 Trackhoe
Excavation Date: November 30, 2004

Figure A-6

TEST PIT TP-7

Depth (feet)	USCS Symbols	Soil Description
0	SM	Dark brown topsoil
	ML	Yellowish gray silt with lenses of silty clay and fine sand (damp)(medium stiff)(sand lenses are water-bearing)
5		
		- torvan reading = 0.9 tsf
10		
15		Test pit completed at a depth of 14 feet on 11-30-04. No groundwater encountered during excavation. No caving occured during excavation.

Excavation Method: Hitachi EX120-5 Trackhoe
Excavation Date: November 30, 2004

Figure A-7

TEST PIT TP-8

Depth (feet)	USCS Symbols	Soil Description
0	SM	Brown topsoil
	SM	Gray silty fine sand with some fine to coarse gravel (damp)(dense)
5		
10		- light cementation and very dense below 10 feet
15		

Test pit completed at a depth of 11 feet on 11-30-04.
No groundwater encountered during excavation.
No caving occured during excavation.

Excavation Method: Hitachi EX120-5 Trackhoe
Excavation Date: November 30, 2004

Figure A-8

TEST PIT TP-9

Depth (feet)	USCS Symbols	Soil Description
0	SM	Dark brown topsoil
	ML/CL	Light gray silt and silty clay (damp to moist)(medium stiff)
		- torvan reading = 0.9 tsf
5	CL	Yellowish silty clay with sand lenses (damp to moist)(medium stiff)(sand lenses are water-bearing)
10		
		- torvan reading = 0.5 tsf
	ML	Gray sandy silt with trace gravel (damp)(stiff)
15		Test pit completed at a depth of 14 feet on 11-30-04. No groundwater encountered during excavation. No caving occured during excavation.

Excavation Method: Hitachi EX120-5 Trackhoe
Excavation Date: November 30, 2004

Figure A-9

TEST PIT TP-10

Depth (feet)	USCS Symbols	Soil Description
0	SM	Dark brown topsoil
	ML	Light gray and yellow, mottled silt (damp to moist)(medium stiff)
5	ML/SM	Light gray to tannish gray sandy silt or silty fine sand (damp)(dense)
		- very dense below 9 feet
10		Test pit completed at a depth of 10 feet on 11-30-04. No groundwater encountered during excavation. No caving occured during excavation.
15		

Excavation Method: Hitachi EX120-5 Trackhoe
Excavation Date: November 30, 2004

Figure A-10

TEST PIT TP-11

Depth (feet)	USCS Symbols	Soil Description
0	SP	Dark brown topsoil
	SM	Light brown silty fine sand with medium to coarse gravel (moist)(medium dense)
		- wet at 3 feet
	ML	Light gray silt and silty clay (damp)(very stiff)
5		
		-difficult digging below 7 feet
		Test pit completed at a depth of 8 feet on 12-1-04. No groundwater encountered during excavation. No caving occured during excavation.
10		
15		

Excavation Method: Hitachi EX120-5 Trackhoe
Excavation Date: December 1, 2004

Figure A-11

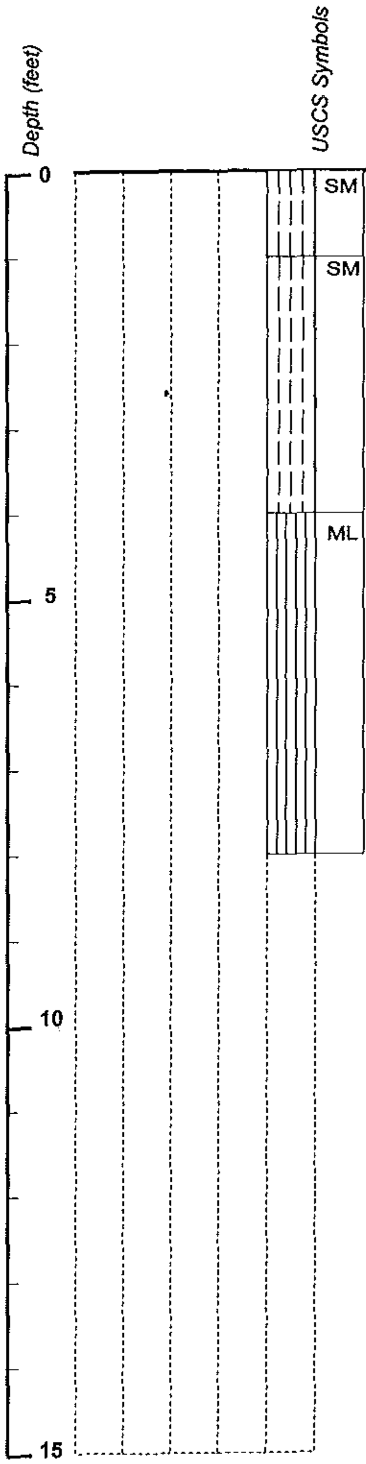
TEST PIT TP-12

Depth (feet)	USCS Symbols	Soil Description
0	SP	Dark brown topsoil
	SM	Gray and brown silty fine to coarse sand with fine to medium gravel (moist to wet)(medium dense to dense)
		- wet below 3 feet
		- dense below 4 feet
5		- lots of cobbles below 5 feet
	ML	Light gray sandy silt with some fine gravel (damp)(stiff)
10		
		Test pit completed at a depth of 13 feet on 12-1-04. No groundwater encountered during excavation. No caving occured during excavation.
15		

Excavation Method: Hitachi EX120-5 Trackhoe
Excavation Date: December 1, 2004

Figure A-12

TEST PIT TP-13



Soil Description

Dark brown topsoil

Gray and brown silty fine sand and sandy silt with trace gravel and cobbles (damp)(medium dense)

Light brown and gray silt with trace gravel and cobbles (damp)(stiff to very stiff)

- difficult digging below 7 feet

Test pit completed at a depth of 8 feet on 12-1-04.
No groundwater encountered during excavation.
No caving occured during excavation.

Excavation Method: Hitachi EX120-5 Trackhoe
Excavation Date: December 1, 2004

Figure A-13

UNIFIED SOIL CLASSIFICATION SYSTEM

SYMBOL	LETTER	DESCRIPTION	MAJOR DIVISIONS			
	GW	WELL-GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	CLEAN GRAVELS (LITTLE OR NO FINES)	GRAVELS MORE THAN HALF OF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE SIZE	FOR VISUAL CLASSIFICATION, THE 1/4" SIZE MAY BE USED AS EQUIVALENT TO THE NO. 4 SIEVE SIZE	COARSE-GRAINED SOILS MORE THAN HALF OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE
	GP	POORLY-GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES				
	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)			
	GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES				
	SW	WELL-GRADED SAND OR GRAVELLY SANDS, LITTLE OR NO FINES	CLEAN SANDS (LITTLE OR NO FINES)	SANDS MORE THAN HALF OF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE SIZE		
	SP	POORLY-GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES				
	SM	SILTY SANDS, SAND-SILT MIXTURES	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)			
	SC	CLAYEY SANDS, SAND-CLAY MIXTURES				
	ML	INORGANIC SILTS, VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY	SILTS & CLAYS LIQUID LIMIT LESS THAN 50			FINE-GRAINED SOILS MORE THAN HALF OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE
	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS				
	OL	ORGANIC SILTS AND ORGANIC SILT-CLAYS OF LOW PLASTICITY				
	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS	SILTS & CLAYS LIQUID LIMIT GREATER THAN 50			
	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS				
	OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS				
	PT	PEAT AND OTHER HIGHLY ORGANIC SOILS	HIGHLY ORGANIC SOILS			

THE NO. 200 U.S. STANDARD SIEVE IS ABOUT THE SMALLEST PARTICLE VISIBLE TO THE NAKED EYE

$\underline{\nabla}$ DEPTH OF GROUNDWATER DURING EXCAVATION

SOIL CLASSIFICATION CHART AND KEY TO TEST PIT LOG